

# DEVELOPMENT OF SUSTAINABLE NATURAL DYED KNITTED GARMENT ENRICHED WITH TIE & DYE TECHNIQUE

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## ABSTRACT

The main idea of extracting dye from plants' (natural) sources is to avoid environmental pollution. Present days with global concern over the use of eco-friendly and biodegradable materials, considerable research work is being undertaken around the world on the application of natural dyes in textile industry. Synthetic dyes and all the processing used in general dyeing are harmful to our health. Dyes derived from natural plant sources have emerged as an important alternative to synthetic dyes. Dye from natural sources can reduce the risk of synthetic dyes. The dyes can be extracted from trees, barks, leaves, flowers and many more sources. Most of the natural dyes also exhibit special properties like anti-microbial, less toxicity, less allergenic, UV protection. This work is aimed to bring out ecofriendly sustainable substantial from different natural source used for extraction of natural dyes, followed by extraction process, and the properties evaluation of fabric dyed by those dyestuffs. Most of the natural dyes showed a very good fastness property in this research study. In this study *Prunus dulcis* (Almond middle shell), *Opuntia basilaris* (prickly pear), *Cascabela thevetia* (Yellow oleander) and *Clitoria ternatea* (Butterfly pea) have been used on cotton knitted SJ fabric and analyzed with fastness properties.

**Keywords:** *Natural dye; Eco-friendly; Extraction Process; Properties; Fastness; almond middle shell; prickly pear; yellow oleander; butterfly pea.*

## 1.INTRODUCTION

Single Jersey is a weft knit fabric sometimes referred to as basic fabric. With just one row of needles, it is knit. The reason why the front and rear faces of this fabric differ from one another is because it has a flat loop structure on one side and a reverse loop structure on the other. Jersey fabric varies significantly depending on the types of fibres it contains. Jersey manufacturers take cotton, wool, or synthetic yarn and load it into an automatic knitting machine.<sup>[1]</sup>

Dyeing fabric and tie-dyeing fabric. Dyeing fabric involves immersing the fabric in a solution containing dye, which bonds with the fabric to change its color. This process can be done in solid colors or patterns. Tie-dyeing, on the other hand, is a technique where fabric is folded, twisted, or tied in various ways before being dyed. This creates colorful patterns and designs on the fabric, often with a distinctive, psychedelic look.

The use of natural dyes dates back thousands of years, with evidence of their use found in archaeological sites around the world. Some of the earliest evidence of natural dyes can be traced back to prehistoric times, where remnants of dyed fibers have been found in caves and ancient settlements. The earliest traces of the use of natural dyes were found in China in the year 2600 BC. Later, colored pigments were found in Egypt in the tomb of King Tutankhamun. Alexander the Great mentioned purple clothing in 541 BC. -inventor of natural dye.<sup>[2]</sup>

The development of natural dyes took place at the same time after the technique of weaving had been discovered in about 5000 BC. In India, the use of natural dyes for dyeing, painting and printing goes to the prehistoric periods. Ajanta paintings, dated as far back as 1st century

AD, were painted with natural dyes. -history of natural dyes in India.<sup>[2]</sup>

The use of natural dyes for textile dyeing purposes decreased largely after the discovery of synthetic dyes in 1856. The effluent problem of synthetic dyes occurs not only during their application in the textile industry, but also during their manufacture and possibly during the synthesis of their intermediates and other raw materials. This has resulted in extensive research on development of natural colorants from natural sources. The advantages of using natural colorants are manifold as they are eco-friendly, safe, easily obtained from renewable sources soft, lustrous and soothing to the human eye. They do not cause health hazards, offer/ offer no disposal problems. India is rich source of colorants. It is estimated that, in India there are some 500 varieties of colorant producing plants from which colorants can be easily extracted.<sup>[3]</sup>

Natural dyes or organic dyes are colors that are extracted from natural resources surrounding our environment; they are extracted from plants, insects and mineral components. These dyes are generally used in coloration of textiles, food, cosmetics and drugs. Most of the affordable dyes are sourced from the plant parts. Muezzart - Eri silk yarn uses roots, leaves, flowers, fruits and even seeds as its natural colorants. This article attempts to review the different types of natural dyes available from plant sources, extraction methods, and fabric dyeing with natural dyes have been discussed.<sup>[4]</sup>

*Cascabela thevetia* L. is a Small evergreen plant species of shrub or small tree belonging to the family Apocynaceae. Common names are be-still tree, captain cook tree, dicky plant, foreigner's tree, lucky nut, Mexican oleander, still tree, yellow oleander, currant-tree. It is a large spreading shrub usually 2.5-3.5m tall. Leaves are spirally arranged along the stem. It is a native of tropical America; especially Mexico and West Indies but has a naturalized in tropical regions worldwide. It is a small tree, the leaves are green, and the colour of the flowers is yellow or orange yellow it shows like trumpet structure. Flowers have odourless; fruits are deep green or black colour. Fruit size is largely it contains milky sap substance which is called Thevetin. Leaves are present waxy coating to reduce the water loss of the plant. When plant turned to aged condition stem change colour greenish to grey. The objective of this study is to extract the natural dye from flowers of *Cascabela thevetia* and dye cotton Single Jersey Fabric<sup>[5]</sup>.

*Clitoria ternatea* is plant species belonging to Fabaceae Family. It is a native plant to Africa and introduced to lowlands of Asia, Central and South America. *C. ternatea* flowers are widely used as herb tea and coloring for food in Southeast Asia. Other than that, it is used as traditional Ayurvedic medicine in India and traditional Chinese medicine<sup>[6,7]</sup> The butterfly pea flower contains a natural blue pigment called anthocyanin, a water-soluble pigment extracted from the blue pea petals and used as a natural dye.

*Opuntia basilaris* (Prickly pears) fruits contain beta lains pigments that provide them with good potential for use as natural dyes or cosmetics. Prickly pear peels refer to

the outer skin or rind of the prickly pear fruit, which is the fruit of the prickly pear cactus (*Opuntia genus*).<sup>[8]</sup>

*Prunus dulcis* (Almond) tropical trees are easily found in the local region and potentially to be exploited as natural dye. The tree produces pink or white flowers, and the fruit is a drupe that contains an edible almond seed.<sup>[9]</sup> The petals are typically soaked in hot water or boiled to extract the pigment, and then the liquid is strained and used as a dye.

Eco friendliness of natural dyes includes Biodegradability, Renewable Resources, Reduced Chemical Usage, Low Energy Consumption, Water Conservation, Cultural and Social Sustainability. This study is completely based on natural dye, which is directly extracted from *Prunus dulcis* (Almond), *Opuntia basilaris* (prickly pear), *Cascabela thevetia* (Yellow oleander) and *Clitoria ternatea* (Butterfly pea). This dye is beneficial for chemical free garments. It is bio - degradable, non-toxic and non-allergenic. It is safer for our skin and for our homes, natural dye can help to create a relaxing and restorative environment.

## 2. MATERIALS AND METHODS

### 2.1 SELECTION OF FABRIC

Single jersey cotton is a soft, stretchy, naturally absorbent, breathable, wrinkle-resistant, and low-maintenance material for ultra-cozy clothing and bedding.



**Fig:1 Cotton knitted Single Jersey fabric**

### 2.2 SELECTION AND COLLECTION OF HERBS

#### 2.2.1 *Cascabela Thevetia* (Yellow Oleander)

*Cascabela thevetia*, commonly known as yellow oleander, is a plant that is native to tropical regions and is known for its attractive appearance and potential medicinal uses. *Cascabela thevetia* is a small, evergreen shrub or tree belonging to the Apocynaceae family. It typically reaches a height of 10-20 feet (3-6 meters) and produces dense clusters of bright yellow, trumpet-shaped flowers.<sup>[5]</sup> These bright yellow flowers which is fresh and disease free, were collected from the agricultural garden near Coimbatore region in the month of September 2023.



**Fig:2** *Cascabela thevetia*

### 2.2.2 *Clitoria Ternate* (Butterfly Pea)

*Clitoria ternatea*, commonly known as butterfly pea flower, is a flowering plant with a rich history of traditional use and a wide range of potential applications. *Clitoria ternatea* is a climbing perennial plant that belongs to the Fabaceae family. It is native to Southeast Asia, but it is now found in various tropical and subtropical regions around the world. Clear blue flowers (2" diameter) with yellowish centers bloom singly or in pairs from summer to fall. Fruits are flattened pods.<sup>[10]</sup>

These bright blue flowers which is fresh and disease free, were collected from the agricultural garden near Tirupur region in the month of September 2023



**Fig:3** *Clitoria ternatea*

### 2.2.3 *Prunus Dulcis* (Almond)

*Prunus dulcis*, commonly known as the almond tree, belongs to the Rosaceae family, known for its nuts, which are referred to as almonds. It is native to the Middle East but is now cultivated in various regions with suitable climates. The tree produces pink or white flowers, and the fruit is a drupe that contains an edible almond seed. Almonds are popular nuts that are used in a variety of culinary applications and have several other uses. Here is an overview of *Prunus dulcis*.<sup>[9]</sup>

These bright pink on middle layer, which is fresh and disease free, were collected from the agricultural garden near Tirupur region in the month of September 2023



**Fig:4** *Prunus dulcis*

### 2.2.4 *Opuntia Basilaris* (Prickly Pear)

Prickly pear cacti are native to the Americas and are commonly found in arid and semi-arid regions. The prickly pear fruit is typically oval or pear-shaped and comes in various colors, including red, orange, and yellow. Prickly pear peels refer to the outer skin or rind of the prickly pear fruit, which is the fruit of the prickly pear cactus (*Opuntia genus*). These peels are often removed to access the juicy and edible pulp inside.<sup>[8]</sup>

These bright reddish inside pulp which is fresh and disease free, were collected from the agricultural garden near Tirupur village side region in the month of September 2023



**Fig:5** *Opuntia genus*

## 2.3 EXTRACTION OF NATURAL DYES

### 2.3.1 Extraction of dye from flowers

1. Selected flowers that are known for their natural dye properties, such as yellow oleander and Butterfly pea. Different flowers will produce different colors of dye.
2. Remove the stems or leaves from the flowers and separate the petals from the rest of the flower.
3. Depending on the amount of dye you want to extract, measure out the appropriate amount of flower petals. A general rule of thumb is to use a 1:2 ratio of flower petals to water by weight.
4. Fill a pot with water and bring it to a boil over medium heat.

5. Once the water is boiling, add the flower petals to the pot. Stir the petals gently to ensure they are fully submerged in the water.

6. Reduce the heat to low and let the flower petals simmer in the water for about an hour. Stir occasionally to help release the dye from the petals.

7. After simmering, remove the pot from the heat and strain the flower petals from the liquid dye. Then use a fine mesh strainer to separate the petals from the dye.

8. Depending on the intensity of the dye, simmer it further to concentrate the color.

9. While the dye is still warm, immerse the selected cotton single jersey sample fabric to dye into the dye bath. The fabric is clean and wet before adding it to the dye bath.

10. Let the sample fabric soak in the dye bath for several hours or overnight, depending on the desired color intensity. Stir the fabric occasionally to ensure even dyeing.

11. Once the sample fabric reaches the desired color, remove it from the dye bath and rinse it thoroughly with water until the water runs clear. Hang the fabric to dry in a well-ventilated area away from direct sunlight.

### 2.3.2 Extraction of dye from fruits (Almond and Prickly pear)

To extract natural dye from fruit for dyeing purposes, you can follow these steps:

1. The selected fruits that are known for their natural dye properties, such as Almond and Prickly pear. Each fruit will produce a different color dye.

2. Wash the fruit thoroughly and remove any leaves, stems or nuts. use fresh fruit for this process.

3. Cut the fruit into small pieces to increase the surface area for extraction.

4. Place the chopped fruit in a pot and cover it with water. Bring the mixture to a simmer over low to medium heat. Simmer for about an hour, stirring occasionally.

5. After simmering, strain the fruit mixture through a fine mesh strainer or cheesecloth to separate the liquid dye from the fruit pulp and seeds. Press down on the pulp to extract as much dye as possible.

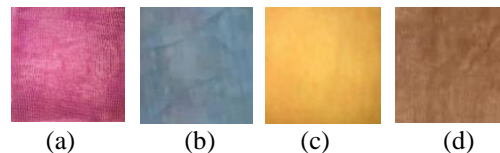
6. Depending on the desired intensity of the dye, add more fruit or reduce the liquid by simmering it further.

9. Once the sample fabric reaches the desired color, remove it from the dye bath and rinse it thoroughly with water until the water runs clear. Hang the fabric to dry in a well-ventilated area away from direct sunlight.

## 2.4 APPLICATION OF NATURAL DYE ON SAMPLE SINGLE JERSEY KNITTED FABRIC

7. While the dye is still warm, immerse the fabric you want to dye into the dye bath. Make sure the fabric is clean and wet before adding it to the dye bath.

8. The sample fabric soak in the dye bath for several hours or overnight, depending on the desired color intensity. Stir the sample fabric occasionally to ensure even dyeing.



**Fig: 6 Natural Dyed Sample Fabrics**  
(a). Prickly pear, (b) Butterfly pea, (c) Yellow Olivander, (d) Almond

## 2.5. EVALUATION OF FABRIC FASTNESS

### 2.5.1 Color Fastness to Washing

#### Procedure:

1. Cut the sample to the size of 2-inch X 2 inch.
2. Cut the standard covering fabric to the sample size.
3. Take distilled water in 1:50 ratio and fully wet the sandwiched specimen for 30 min.
4. Now place the dried sample between two plastic plates and place all plastic plates one above the other.
5. Now transfer the plates onto the bottom metal plate.
6. Place the top metal plate and adjust the load with the help of thumb screws.
7. Then keep the loaded instrument in the air oven for 4 hours at a temperature of  $38 \pm 1^\circ\text{C}$
8. After 4 hours remove the sample specimen from the instrument and remove the stitching. Compare the test specimen with the original



sample for change in color compare with scale also.

9. Compare the standard covering cloth with the fresh sample.

Wash fastness is a crucial characteristic of dyes, whether they are synthetic or natural. It describes a dye's capacity to hold onto its color after going through various washing and laundering procedures. The type of dye, the mordants used, and the cloth to which the dye is applied can all affect how washable natural dyes are. It is decisive to consider that natural dyes often have poorer wash fastness compared to synthetic dyes. Several methods and procedures, such as the use of mordants, dye fixatives, and post-treatment procedures, can be used to increase the wash fastness of natural dyes. Additionally, choosing dyes recognized for their excellent wash fastness and employing suitable dyeing methods might aid in getting superior outcomes.

The washability of various natural dyes varies. And the wash fastness of natural dyes can also be affected by the mordant chosen. Here there is no mordants are used to fixing the color. The wash fastness of a natural dye can also be influenced by the type of fabric to which it is applied.

### 2.5.2 Color Fastness to Sunlight

Light fastness is the resistance to fading of dyed textiles when exposed to daylight. Exposure to sunlight behavior of the sample under actual conditions of use takes long time. In standard condition-The sample and standards are mounted half covered and half exposed to daylight. The sample must be protected from rain by a glass sheet not less than Sem away (well ventilation due to moisture and heat). The specimen and standards should be kept under sun and continue 24hrs until sufficient fading. 3 Reference sample and the tested sample are cut at same accommodated on the template. The specimens are mounted in a frame facing south in the northern hemisphere and facing north in the southern hemisphere at an angle equal to the latitude of the place. The way of carrying out the test is to mount the standards and specimens. The sample must be protected from rain by a glass sheet. One quarter of the sample and standards are covered with opaque fabric. Thus, it is exposed until standard-I will be fade and equivalent to standard-4 on change in color grey scale. Then cover up one quarter of the previously exposed portion of the sample and standards with another sheet. Thus, it is exposed until standard-7 will be fade and equivalent to standard-4 on change in color grey scale.

## 2.6 DESIGN AND DEVELOPMENT OF PRODUCT

### 2.6.1 Single Jersey T-Shirt Production

#### Pattern making and drafting:

Take accurate measurements of the person who will wear the T-shirt. This includes chest circumference, waist circumference, shoulder width, sleeve length, and desired T-shirt length. Using the measurements, draft a pattern on paper. You can find T-shirt pattern templates online or create one from scratch using the measurements.



**Fig: 7 Pattern drafting**

#### Cutting, Sewing and trimming

The fabric must be spread on the table without any wrinkles. Place the pattern on the fabric and mark the pattern. Cut the fabric with seam allowance. Use the pattern to cut out fabric pieces for the front, back, sleeves, and neckline. Sew shoulder seams together, then attach sleeves to the body of the T-shirt. Sew the side seams from the sleeve hem to the bottom hem, creating the T-shirt's silhouette.



**Fig: 8 Cutting and Sewing**

### 2.6.2 Tie & Dye Printing Technique applied on produced T-Shirt

Tie-dyeing is a hand dyeing technique whereby numerous little pieces of material are gathered and securely tied with string before the cloth is submerged in the dye bath to create colorful patterns.



**Fig: 9 Tie & Dye technique applied on T-Shirt**



**Fig: 10 Final Product Images**

### 3.RESULT AND DISCUSSION

#### 3.1 COLOR FASTNESS TO WASHING

Color fastness to washing refers to the ability of a fabric or textile dye to withstand repeated washing without fading or bleeding. It's an important characteristic, especially for clothing and textiles that are expected to undergo frequent laundering.

##### 3.1.1 *Prunus Dulcis* Dyed Sample



**Fig:10 *Prunus Dulcis* Washing Sample**

**Table:1 Evaluation of *Prunus Dulcis* dyed sample for Washing Fastness**

Name of Component	Grade	Degree of Fades
<i>Prunus dulcis</i>	Grade 7	High Color
<i>Prunus dulcis</i>	Grade 6	Slightly Faded
<i>Prunus dulcis</i>	Grade 4	Slightly Faded

Color fastness test might be more important depending on the design and intended use of textile products. Standards test for color fastness to water wash, soap and other unique conditions. The result was finding that the color fastness properties of a *Prunus dulcis* in Cotton knitted fabric is good and the color fastness is outstanding after 6 washes.

##### 3.1.2 *Clitoria Ternatea* Dyed Sample



**Fig:11 *Clitoria Ternatea* Washing Sample**

**Table:2 Evaluation of *Clitoria Ternatea* dyed sample for Washing Fastness**

Name of Component	Grade	Degree of Fades
<i>Clitoria ternatea</i>	Grade 7	High Color
<i>Clitoria ternatea</i>	Grade 6	Slightly Faded
<i>Clitoria ternatea</i>	Grade 4	Slightly Faded

Color fastness test might be more important depending on the design and intended use of textile products. Standards test for color fastness to water wash, soap and other unique conditions. Result was finding that the color fastness properties of a *Clitoria ternatea* in Cotton knitted fabric is good and the color fastness is outstanding after 6 washes.

##### 3.1.3 *Opuntia Basilaris* Dyed Sample



**Fig:12 *Opuntia Basilaris* Washing Sample**

**Table:3 Evaluation of *Opuntia Basilaris* dyed sample for Washing Fastness**

Name of Component	Grade	Degree of Fades
<i>Opuntia basilaris</i>	Grade 7	High Color
<i>Opuntia basilaris</i>	Grade 6	Slightly Faded
<i>Opuntia basilaris</i>	Grade 4	Slightly Faded

Color fastness test might be more important depending on the design and intended use of textile products. Standards test for color fastness to water wash, soap and other unique conditions. The result was finding that the color fastness properties of a *Opuntia basilaris* in Cotton knitted fabric is good and the color fastness is outstanding after 6 washes.

##### 3.1.4 *Cascabela Thevetia* Dyed Sample



**Fig:13 *Cascabela Thevetia* washing sample**

**Table:4 Evaluation of *Cascabela Thevetia* dyed sample for Washing Fastness**

Name of Component	Grade	Degree of Fades
<i>Cascabela thevetia</i>	Grade 7	High Color
<i>Cascabela thevetia</i>	Grade 6	Slightly Faded
<i>Cascabela thevetia</i>	Grade 4	Slightly Faded

Color fastness test might be more important depending on the design and intended use of textile products. Standards test for color fastness to water wash, soap and other unique conditions. The result was finding that the color fastness properties of a *Cascabela thevetia* Cotton knitted fabric is good and the color fastness is outstanding after 6 washes.

### 3.2 COLOR FASTNESS TO SUNLIGHT

Color fastness to sunlight, also known as lightfastness, refers to the ability of a material, such as a fabric or dye, to resist fading or discoloration when exposed to sunlight or other sources of light over time. Sunlight contains ultraviolet (UV) radiation, which can break down the chemical bonds in dyes and pigments, leading to fading or changes in color.

#### 3.2.1 *Prunus Dulcis* Dyed Sample



**Fig:14 *Prunus Dulcis* sunlight sample**

**Table:5 Evaluation of *Prunus Dulcis* dyed sample for Fastness to Sunlight**

Name of the Component	Grade	Degree of Fading
<i>Prunus dulcis</i>	Grade 7	No Faded
<i>Prunus dulcis</i>	Grade 7	No Faded

Color fastness to sunlight refers to the ability of the fabric to withstand the daylight. The resistance properties of the below dyes are evaluated and resulted. It gives good and excellent color fastness to the Cotton knitted fabric.

#### 3.2.2 *Clitoria Ternatea* Dyed Sample



**Fig:15 *Clitoria Ternatea* sunlight Sample**

**Table:6 Evaluation of *Clitoria Ternatea* dyed sample for Fastness to Sunlight**

Name of the Component	Grade	Degree of Fading
<i>Clitoria ternatea</i>	Grade 7	Highly
<i>Clitoria ternatea</i>	Grade 4	Slightly Faded

Color fastness to sunlight refers to the ability of the fabric to withstand the daylight. The resistance properties of the below dyes are evaluated and resulted. It gives good and excellent color fastness to sunlight in Cotton knitted fabric.

#### 3.2.3 *Opuntia Basilaris* Dyed Sample



**Fig:16 *Opuntia Basilaris* Sunlight Sample**

**Table:7 Evaluation of *Opuntia Basilaris* dyed sample for Fastness to Sunlight**

NAME OF THE COMPONENT	GRADE	DEGREE OF FADING
<i>Opuntia basilaris</i>	Grade 7	Highly
<i>Opuntia basilaris</i>	Grade 5	Slightly Faded

Color fastness to sunlight refers to the ability of the fabric to withstand the daylight. The resistance properties of the below dyes are evaluated and resulted. It gives good and excellent color fastness to the Cotton knitted fabric.

#### 3.2.4 *Cascabela Thevetia* Dyed Sample



**Fig:17 *Cascabela Thevetia* Sample**

**Table:8 Evaluation of *Cascabela Thevetia* dyed sample for Fastness to Sunlight**

Name of the Component	Grade	Degree of Fading
<i>Cascabela thevetia</i>	Grade 7	Highly
<i>Cascabela thevetia</i>	Grade 6	Slightly Faded

Color fastness to sunlight refers to the ability of the fabric to withstand the daylight. The resistance properties of the above dyes are evaluated and resulted. It gives good and excellent color fastness to sunlight in Cotton knitted fabric.

#### 4. CONCLUSION

Due to the non-biodegradable and carcinogenic nature associated with the synthetic dyes, people started using natural colours. The whole process of dye extraction and dying of cotton is ecologically safe. There are much research works that has been carried out by many researchers/scientists belonging to industry, small and medium entrepreneurs, social and Government organizations, researchers in various educational institute etc, on the revival of natural dyes, but more research is required to standardize the methods for its application. In this study various natural plant sources were selected for the dye extraction, which was applied on the self-produced cotton single jersey T-shirts for men enhanced with Tie and dye printing Technique. Thus, the objective of the study reveals to create beautiful and unique colors from natural sources, such as plants, animals, minerals, and microbes. To reduce the environmental impact of dyeing, such as water waste, chemical pollution, and energy consumption. To preserve the cultural and traditional knowledge of natural dyeing practices around the world. To explore the functional properties and health benefits of natural dyes, such as antibacterial and antifungal. To enhance the artistic expression and creativity of dyeing by using the tie-dye method.

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